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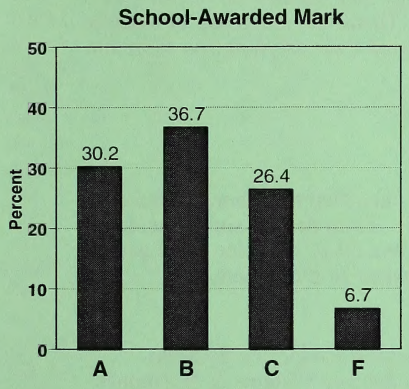
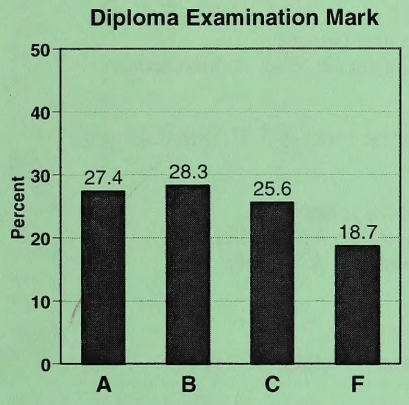
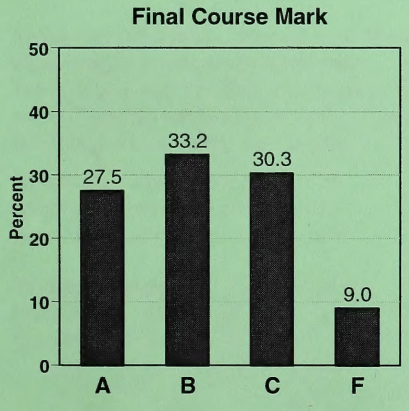
Biology 30

Diploma Examination Results
Examiners' Report for June 1999







The summary information in this report provides teachers, school administrators, and students with an overview of results from the June 1999 administration of the Biology 30 Diploma Examination. This information is most helpful when used in conjunction with the detailed school and jurisdiction reports that are provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined January, April, June, and August results is made available annually.

Description of the Examination

The Biology 30 Diploma Examination consists of 48 multiple-choice questions worth 60%, eight numerical-response questions worth 10%, and two written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 8 781 students in Alberta who wrote the June 1999 examination and received a school-awarded mark.

- 91.0% of the 8 781 students achieved the *acceptable standard* (a final course mark of 50% or higher).
- 27.5% of the 8 781 students achieved the *standard of excellence* (a final course mark of 80% or higher).

Generally, student achievement in Biology 30 was good. The percentage of students who achieved the *acceptable standard* (91.0%) was essentially the same as the percentage for June 1998 (90.8%). Most students demonstrated a very good understanding of the nervous system, reproductive hormones and systems, Mendelian genetics, and population genetics and interactions tested on this exam. Students had the most difficulty with concepts involving embryonic differentiation and development especially when combined with concepts on meiosis and mitosis and gene mutation and inheritance. Most students demonstrated an understanding of core concepts in the course and many students could apply these concepts to demonstrate a good understanding of science, technology, and society connections.

Approximately 62.0% of the students who wrote the June 1999 examination were female. Of these, about 91.8% achieved the *acceptable standard* for a final course mark, compared with 89.7% of the male students. Approximately 26.8% of the female students achieved the *standard of excellence* for a final course mark, compared with 28.7% of male students.

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Provincial Averages

- The average school-awarded mark was 70.3%.
- The average diploma examination mark was 66.6%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 68.8%.

Approximately 4.2% of the students who wrote the examination in June 1999 and received a school awarded mark had written at least one other Biology 30 diploma examination during the June 1998 to June 1999 period. This subpopulation (365) achieved an average examination mark of 56.6% compared with 67.1% for the population (8 416) who wrote a Biology 30 examination for the first time in June 1999. However, the group of students who rewrote increased their examination score on average by 9.4%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the *acceptable standard* will obtain a mark of 50% or higher, and students achieving the *standard of excellence* will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score (out of 1) achieved by students who wrote the examination.

Questions are also classified by general learner expectations (GLE). Even though some questions address more than one GLE, only one GLE was selected for the purpose of this report.

Knowledge:

GLE 1 Nervous & Endocrine Systems
GLE 2 Reproductive Systems & Hormones
GLE 3 Differentiation & Development
GLE 4 Cell Division & Mendelian Genetics
GLE 5 Molecular Genetics
GLE 6 Population Genetics & Interaction

Skills:

SPC Scientific Process & Communication Skills

Science, Technology, Society:

STS Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC1	D	0.629	✓						✓	✓
MC2	A	0.527					✓			
MC3	C	0.639	✓							
MC4	C	0.716	✓							
MC5	D	0.448	✓							
MC6	C	0.539					✓			✓
MC7	D	0.836	✓							✓
MC8	D	0.728	✓						✓	
MC9	D	0.659	✓						✓	
MC10	C	0.621	✓							✓
MC11	C	0.834	✓							✓
MC12	B	0.419			✓					✓
MC13	A	0.656	✓							✓
MC14	D	0.814	✓							
MC15	D	0.814	✓						✓	
MC16	A	0.664	✓							
MC17	C	0.762		✓						
MC18	C	0.550		✓						
MC19	B	0.699		✓						
MC20	A	0.822		✓						
MC21	B	0.826				✓			✓	
MC22	B	0.800		✓					✓	

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC23	C	0.781		✓						
MC24	A	0.681		✓						
MC25	C	0.627		✓						
MC26	D	0.880			✓					✓
NR1	1342	0.823			✓					
NR2	2431	0.546			✓					
MC27	A	0.387			✓					✓
MC28	B	0.795					✓		✓	
NR3	3214	0.801				✓				
NR4	321	0.792				✓			✓	
MC29	B	0.570				✓			✓	✓
MC30	D	0.684				✓			✓	✓
MC31	C	0.810		✓						✓
MC32	B	0.751				✓				
MC33	D	0.751				✓			✓	
NR5	0.50	0.760				✓			✓	
MC34	C	0.722				✓			✓	
NR6	0	0.658				✓			✓	
MC35	A	0.818				✓			✓	
MC36	A	0.644				✓			✓	
NR7	0.2	0.444						✓	✓	
MC37	C	0.722				✓			✓	
NR8	50	0.627				✓			✓	
MC38	B	0.831						✓	✓	
MC39	D	0.800						✓		✓
MC40	B	0.690					✓			✓
MC41	B	0.760						✓	✓	
MC42	A	0.820						✓		✓
MC43	A	0.785						✓		✓
MC44	B	0.775						✓	✓	✓
MC45	A	0.658						✓		
MC46	D	0.386						✓	✓	✓
MC47	D	0.834						✓		
MC48	C	0.617						✓	✓	
WR1	—	0.530	✓(7)			✓(2)	✓(3)		✓(6)	✓(5)
WR2	—	0.639				✓	✓	✓	✓	✓

Subtest: Machine Scored and Written Response (Average by Subtest)

Subtests: Machine Scored and Written Response (Average by Subtest)
When analyzing detailed results, bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

Machine scored: 39.0 out of 56
Multiple choice: 33.6 out of 48
Numerical response: 5.5 out of 8

Written Response: 17.7 out of 30
Question 1: 6.4 out of 12
Question 2: 9.6 out of 15

Raw Score Averages for Machine-Scored Items and Written-Response Question 1 by General Learner Expectations

General Learner Expectations:

GLE 1	Nervous & Endocrine Systems	12.9	out of	20
GLE 2	Reproductive Systems & Hormones	6.5	out of	9
GLE 3	Differentiation & Development	3.1	out of	5
GLE 4	Cell Division & Mendelian Genetics	10.8	out of	16
GLE 5	Molecular Genetics	4.4	out of	7
GLE 6	Population Genetics & Interaction	7.7	out of	11
SPC	Scientific Process & Communication Skills	20.3	out of	30
STS	Science, Technology, & Society Connections	14.4	out of	23

Multiple-Choice and Numerical-Response Questions

The following table gives results for seven questions selected from the examination and shows the percentage of students in four groups that answered each question correctly. The comments following the table relate to some of the understandings and skills the students may have used to answer these questions.

Percentage of Students Correctly Answering Selected Machine-Scored Questions

	Question Number						
Student Group	**MC5**	**MC12**	**MC24**	**MC28**	**NR5**	**NR7**	**MC40**
All Students	44.8	41.9	68.1	79.5	76.0	44.4	69.0
Students achieving the *standard of excellence* (80% or higher, or A) on the whole examination	77.8	65.4	94.8	94.3	91.9	81.8	92.5
Students achieving the *acceptable standard* but not the *standard of excellence* (50% to 79%) on the whole examination	36.1	37.7	67.1	79.1	75.7	38.0	67.8
Students who have not achieved the *acceptable standard* (49% or less, or F) on the whole examination	21.5	19.5	32.0	58.8	53.4	8.2	37.8

Use the following information to answer the next question.

> Two symptoms of Parkinson's disease are lack of muscular coordination and tremors, both caused by inadequate amounts of dopamine. Symptoms of Alzheimer's disease include the deterioration of memory and mental abilities, possibly caused by a decrease in acetylcholine production.
>
> Dopamine and acetylcholine are excitatory neurotransmitters in various parts of the brain.

5. What role do both dopamine and acetylcholine have when they function as excitatory neurotransmitters?

- **A.** They make the presynaptic membrane more permeable to K^+ ions.
- **B.** They make the presynaptic membrane more permeable to Na^+ ions.
- **C.** They make the postsynaptic membrane more permeable to K^+ ions.
- ***D.** They make the postsynaptic membrane more permeable to Na^+ ions.

Multiple-choice question 5 required students to identify the role of two excitatory neurotransmitters. Students achieving at the *standard of excellence* could readily identify that the neurotransmitters increase permeability of the post-synaptic membrane to Na^+ ions. Most other students had some degree of difficulty. The most common error was the choice of alternative B, which may indicate that these students did not know that neurotransmitters act on the post-synaptic membrane after diffusing across the synapse.

Use this additional information to answer the next question.

> Certain mercury compounds are able to cross the placenta and thereby affect embryological development.
>
> –from *Hedegard, 1993*

12. Exposure to mercury compounds during embryological development would **most likely** disrtupt the

- **A.** production of amniotic fluid
- ***B.** development of the neural tube
- **C.** production of ovarian hormones
- **D.** development of the umbilical cord

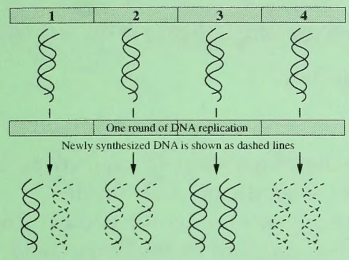
Multiple-choice question 12 required students to reason that mercury compounds would most likely disrupt development of the neural tube during embryological development. Initial context information identified that mercury poisoning causes neurological damage; therefore, students should have chosen a disruption of neurological development as the most likely effect. Most students had difficulty with this question. Students continue to have difficulty with concepts related to embryological development.

24. Hormones that stimulate the production of testosterone are transported by the

*A. blood
B. vas deferens
C. seminiferous tubules
D. ducts from the gland secreting the hormones

Use the following information to answer the next question.

Four Theoretical Models of DNA Replication



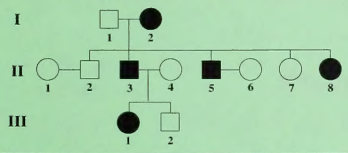
28. Which number represents the model of DNA replication that occurs in human cells?

*A. 1
B. 2
C. 3
D. 4

Use the following information to answer the next question.

Piebald spotting is a rare human disorder. Although this disorder occurs in all races, piebald spotting is most obvious in people with dark skin. A dominant allele appears to interfere with the migration of pigment-producing cells; thus, patches of skin and hair lack pigment, allowing "spots" to form.

Pedigree Chart for Piebald Spotting



Numerical Response

5. What is the probability that any offspring produced by individuals II-5 and II-6 would have piebald spotting?

(Record your **answer as a value from 0 to 1 rounded to two decimal places** in the numerical-response section on the answer sheet.)

Answer: 0.50

Multiple-choice question 24 required students to recall the major concept that testosterone, like all hormones, is transported in the blood. Most students could readily answer this question. The most common error was to choose alternative D, which indicates that the ducts from the glands that secrete testosterone also transport it. This indicates that these students did not differentiate between endocrine glands, which secrete hormones directly into the blood, and exocrine glands, which secrete other substances using ducts.

Multiple-choice question 28 required students to select the correct diagram representing the model of DNA replication (semi-conservative replication) that occurs in human cells. This is a major concept in the unit on molecular genetics. Students did very well on this question, with a large percentage of the students who had difficulty on the examination overall correctly answering the question. This demonstrates that students who have not quite achieved the acceptable standard in Biology 30 may still have mastered many important concepts in the course.

Numerical-response question 5 is a two-part problem-solving question. Students had to determine the genotypes of two individuals represented in a pedigree for piebald spotting and then calculate the probability of a cross between these two individuals producing offspring with the disorder. Most students could readily solve this two-part problem, including many students who did not achieve the acceptable standard on this examination.

Use the following information to answer the next question.

A program to detect carriers of β-thalassemia (a mild blood disorder) found the incidence of the disease to be 4% in a particular population. A recessive allele found on an autosomal chromosome causes β-thalassemia.

Numerical Response

7. What is the frequency of the recessive β-thalassemia allele in the gene pool of this population?

(Record your **answer as a value from 0 to 1 rounded to one decimal place** in the numerical-response section on the answer sheet.)

Answer: 0.2

Use the following information to answer the next question.

A bacterium has been found that produces a form of plastic called polyhydroxybutyrate (PHB). Genes from this bacterium have been transferred into a weed called *Arabidopsis thaliana*. These weeds now produce a biodegradable plastic.

—from *Poirie, et al., 1997*

40. The technology of transferring a gene from a bacterium into a green plant is based on the principle that

A. all genes carry the same genetic information

***B.** all genes have the same basic chemical components

C. The genotypes of the bacterium and green plant are the same

D. The phenotype of an organism is not altered when one gene is exchanged for another

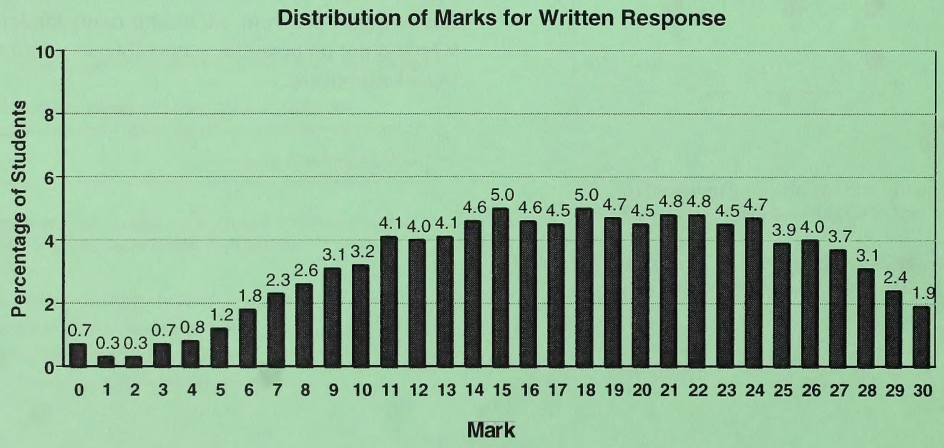
Numerical-response question 7 required students to calculate the frequency of a recessive allele in a given population. Students achieving at the *standard of excellence* could readily calculate this frequency. Most other students had difficulty with the calculation. Students' most common error was to express the frequency as 0.04, which is the frequency of the recessive disorder in the population. These students did not complete the calculation:

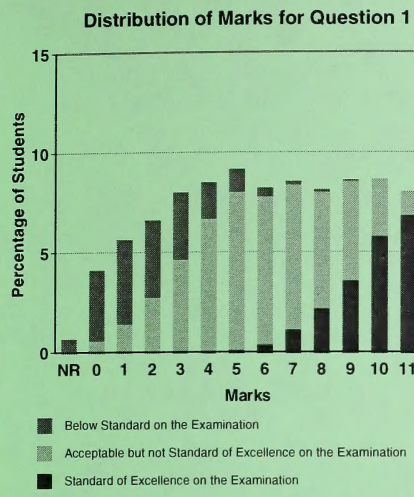
$q^2 = \frac{4}{100}$, $q = 0.2$, where q is the recessive allele frequency.

Multiple-choice question 40 required students to identify the scientific principle that the technology of gene transfer is based on. Students achieving the *standard of excellence* could readily identify the principle. Students who had difficulty with this question most often chose alternative C. This indicates that these students do not understand that the building blocks of DNA in plants and bacterium are the same, however, the nitrogen bases are arranged in different sequences to create unique genes in the two types of organisms. This is a basic concept in the unit on molecular genetics.

Written-Response Questions

Of the students who wrote the June 1999 examination, 0.7% received no marks for both written-response questions, 66.3% received 15 marks or more out of 30, and 23.7% received 24 marks or more out of 30. The average for the written-response questions was 58.9%.





For **Question 1**, approximately 95.2% of the students who wrote this examination received some marks on this process skill question relating to the effects of the Chernobyl nuclear reactor explosion on the physiology and health of the population living in the area. Aspects of this environmental issue that were presented included the effects of exposure to radiation on the thyroid gland of children in the area, treatment of the resulting disorders, and the long-term effects on the population of mutations that were passed on to the next generation.

The mean for part a. was approximately 60.5%. Those students who did well on the question overall could clearly explain one function of thyroxine. However, weaker students' responses commonly referred to the information in the context, rather than course knowledge, to incorrectly hypothesize that the function of thyroxine is to control iodine levels in the blood.

The mean for part b. was approximately 54.1%. Most students could correctly indicate that thyroxine is released by the thyroid gland. Students who did well on the question overall could draw a complete feedback loop including appropriate symbols, such as a dashed line or a negative sign to indicate negative feedback. Weaker student responses included extra steps in their feedback loop, often included other glands or hormones in addition to the correct ones, and/or did not communicate by using a feedback loop illustration.

The mean for part c. was approximately 55.8%. Most students could correctly identify at least one symptom caused by the absence of thyroxine in an infant. Strong responses stated two symptoms clearly. A symptom has to be observable. Weak responses included effects of an absence of thyroxin that were not observable.

The mean for part d. was 48.3%. Many students had difficulty explaining why non-radioactive iodine would be used as a treatment for children exposed to radioactive iodine. Students who clearly understood the role of iodine in thyroxin production were able to answer this question clearly and concisely. Their responses showed an understanding of how the gland absorbs iodine to produce thyroxine, and of the concepts of saturation or dilution in minimizing the effects of the radioactive iodine. Weak responses indicated either a lack of knowledge of the link between iodine and thyroxine production or an inability to apply this knowledge to a unique problem.

The mean for part e. was approximately 62.4%. Most students could identify a mutation in a strand of bases. Students who did well on the question overall clearly indicated a mutation in DNA and described the mutation illustrated. They often supplied additional information that was not required which showed the mRNA translation, and the amino acids that would result form the mutated DNA strand. Weak responses illustrated a "mutation" in mRNA bases or a mixture of DNA and mRNA bases, which indicates that these students were unsure of the composition of DNA or that a mutation occurs in DNA not mRNA.

The mean for part f. was approximately 33.0%. Most students had some difficulty with this part of the question. Students often missed the concept that a mutation in a germ-line cell is reproduced during mitosis in every cell of the embryo arising from a fertilized egg. Students who had difficulty with this question overall often described an infection of the white blood cells in their answers, which shows that they confused the term "germ-line cell" with the word "germ." These students did not clearly understand the concept of an inheritable mutation. Those students who did well on the question overall demonstrated a clear understanding of this concept in most instances.

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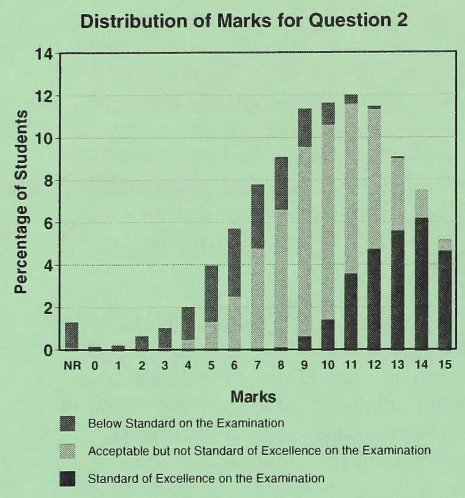

For **Question 2**, approximately 98.6% of the students who wrote this examination received some marks on this extended-response question. The overall mark on this question was approximately 63.9%. The question required students to discuss various aspects of the technology of xenotransplantation using pigs.

The average on the Science scale for this question was approximately 69.5%. Most students compared traits of the pigs that contributed to its relatively high biotic potential with another mammal, usually humans. However, many students' responses failed to directly compare the biotic potential of pigs with another mammal. It was not clear from these responses whether some students understood the meaning of the term "biotic potential." Students could readily select traits of the pigs that would have led researchers to choose them for xenotransplantation. Weak responses failed to clearly explain why these traits made the pigs suitable for xenotransplantation. Almost all students could communicate the outcome of a heterozygous cross clearly using a Punnett square. Most students attempted to explain why researchers performed crosses of heterozygote offspring, and they often indicated in their responses that homozygous pigs would be produced. However, many students failed to complete their explanations by either indicating that homozygous transgenic pigs would be useful as breeding stock and/or that these pigs' hearts would be less likely to be rejected in a transplant.

The average mark on the Technology and Society scale was approximately 52.9%. Students who did well on this part of the question could accurately describe a technology that might be used to locate the HDAF gene. Many other students gave incomplete or inaccurate descriptions of the technology or described the process of producing a transgenic pig rather than a technology used to obtain the HDAF gene. The most difficult part of this question for most students was explaining why some normal offspring were produced after injection of the HDAF gene into fertilized eggs. In order to answer this question well, students had to clearly understand that the fertilized eggs that were injected with the HDAF gene would develop into pigs through the process of mitosis and cell specialization, that all cells of an organism contain the genes present in the original fertilized egg, and that the human HDAF gene needed to be incorporated into the pig DNA in the fertilized egg in order to be reproduced in the cells of the pig. Students often described the fertilized egg as undergoing divisions to produce many offspring, of which some contained the HDAF gene and some lacked the gene. This incorrect response shows an error in the understanding of the processes that occur after fertilization of an egg. These responses also seemed to demonstrate a confusion between the processes of mitosis, which occurs during the development of the embryo from the fertilized egg, and meiosis, which occurs in the process of producing the egg. Similar errors in students' understanding were demonstrated in incorrect responses for written-response question 1, part f.

In general, the students demonstrated good communication skills by including written descriptions and explanations and a clear Punnett square illustration. Students' responses were well organized and, for the most part, clear and concise. Most students addressed all aspects of the question.

For further information, contact Elisa Rawe erawe@edc.gov.ab.ca, Donna Matovinovic dmatovinovic@edc.gov.ab.ca, or Corinne McCabe cmccabe@edc.gov.ab.ca at the Student Evaluation Branch at (780) 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.

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